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Decentralised energy, decentralised accountability? Lessons on how to govern decentralised electricity transitions from multi-level natural resource governance

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ABSTRACT

Emerging decentralised electricity systems require new approaches to energy governance. As energy sources shift and technology evolves, electricity governance is shifting from largely centralized models to include multiple decentralised and multi-level sites not bounded in their operations by established democratic processes. New forms of accountability are required to ensure that multi-level electricity systems meet societal needs and expectations. While multi-level governance dynamics are new for many electricity systems, they are common across other resources (e.g. water). This article uses an OECD framework that synthesizes decades of research on multi-level natural resource governance to describe 12 principles for "good" resource governance. These principles are developed and applied to decentralising electricity governance contexts in order to develop mechanisms, and identify potential governance gaps, that are relevant for ensuring accountability in decentralised electricity governance systems. The nature of decentralised electricity systems particularly highlights the need to rescale many governance functions, while paying attention to issues of inclusion, capacity building, coherence, adaptiveness, and transparency.

1. Introduction

Decentralisation is a defining feature of the ongoing energy transition. Fuelled by falling technology costs, rising concern over climate change, and social innovation opportunities, electricity generation in particular is moving away from largely predominant centralized models [1].[1] While decentralisation presents many technical, environmental and social opportunities [2–4], it also introduces governance challenges [5,6]. The increasing proportion of decentralised electricity generation assets in supply mixes means that there are many more actors playing important roles in energy systems. These new dynamics complicate the tasks of authorities accountable for ensuring adequate, clean, and affordable electricity for society. The objective of this paper is to draw upon insights from decentralised natural resource governance contexts to develop mechanisms, and identify potential governance gaps, that are relevant for ensuring accountability in decentralised electricity governance systems.

Accountability in governance is the allocation, acceptance and demonstration of responsibility for actions and decisions [7,8]. In contemporary electricity governance, accountability mechanisms evolved in step with centralized generation models [5,9]. Centralized models involve a limited number of generation assets that produce power that flows to consumers through a centrally controlled grid. If governance is defined as the actions and decisions taken regarding a particular resource [10], then the number of actors directly involved in centralized electricity governance systems is relatively constrained. Governing tasks are usually handled centrally by a system regulator, in consultation with industry actors, and under policy direction from a democratically elected government. Chains of accountability are well established, and relatively clear [6].

Decentralised electricity systems have a fundamentally different

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[1] The move from centralisation to decentralisation is not consistent across all contexts. For example [55], discuss previously decentralised systems in Berlin and Hong Kong that emerged as a result of geopolitical isolation.

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system architecture [11]. As decentralised assets proliferate and many consumers shift to being "prosumers" (i.e. those who both produce and consume electricity), electricity systems are increasingly characterized by a mix of centralised and decentralised generation assets. This requires new governance models. Decentralised governance can be structured in many ways. However, all iterations involve a rescaling of governing activities, and an increase in both the number of actors and in overall system complexity [12,13]. This has implications for how accountability for the generation and provision of electricity is ensured.

Widespread decentralisation of supply is a relatively new development in modern electricity contexts. However, there are many resources for which a mix of centralised and decentralised supplies have long been used to meet critical societal needs. For example, water is often provisioned through a mix of central resources (e.g. pipelines that feed water from the Colorado River to California farmers), city- and town-level distributions systems, and private or semi-private wells. The entire system is coordinated by accountable, centralised authorities in a multi-level, nested manner in order to ensure that people and businesses have a safe, secure and reliable supply of water. While the comparison between water and electricity resources is certainly not perfect (discussed below), the extensive scholarship on how to accountably govern multi-level resources such as water holds important insights for the governance of a decentralising electricity system.

This paper draws upon the rich literature on accountability in nested, multi-level and participatory water governance systems to develop mechanisms, and identify potential governance gaps, relevant for decentralised electricity governance. It first establishes the basis – and limitations – for comparing water and electricity resource governance systems for the purposes of ensuring accountability. It then reviews the concept of "accountability" in the context of nested, multi-level and participatory governance. The article then introduces the (2015) Organisation for Economic Cooperation and Development (OECD) principles for "good" water governance. The principles were explicitly designed to address challenges of accountability and other critical "governance gaps". The next section briefly introduces a case of multi-level water governance in Ontario, Canada that will be used to ground the OECD principles in empirical reality. After that, the OECD principles are described, and then discussed as relevant – or not – for accountable electricity governance. The article closes with an overview of relevant mechanisms and gaps.

2. Comparing water and electricity governance

Water governance is highly studied both because it is an essential societal resource, and because it tends to function as a "common pool" resource (CPR). These are resources for which users are in competition (i.e. the resource is finite), it is not possible to exclude others from the resource, and users are interdependent. As a result, the actions of one user have implications for the ability of others to use or benefit from the resource. When the behaviour of individual actors participating in the system impacts the entire system, governance must coordinate across these actors [14].

In such CPR contexts, governance tends to be "multi-level". Multi-level governance requires the coordination and cooperation of actors at multiple levels [15]. A specific variant of multi-level governance is "nested" governance. This is governance that occurs "in the shadow of hierarchy" [16]. Nested governance, adapting a definition from resource governance contexts, is "a mechanism to provide social benefits through decentralised and community-based [resource] management, while addressing causes and consequences of social, [ecological, and technical] issues crossing spatial and jurisdictional scales" [17]:59). It is common where a central government or authority has formal accountability for ensuring access to a resource. There are clear, formally codified relationships delineating governing tasks and responsibilities. However, decentralised decision-making units retain a significant measure of autonomy [18,19].

Centralised electricity systems have not traditionally assumed the characteristics of CPRs. Among other reasons, users of the electricity grid were not interdependent; that is, their actions and decisions did not directly impact the ability of their neighbours to use the grid. User actions and decisions were (and often still are) mediated by a central authority, independent of other users. However, the proliferation of grid-connected decentralised generation resources has changed the nature of the grid use, with clear implications for governance. This is for two main reasons:

First, trends toward decentralisation and prosumption mean that people in close geographical proximity can be in competition for "space" on the grid.[2] Additionally, locally produced electricity can be in short supply, creating the need for back up from the wider system. This type of situation – where coordination is required amongst geographically close actors who are linked by common infrastructure – begins to resemble governance architectures associated with common pool resources like water.

Second, the emerging grid architecture – where a high fraction of decentralised renewables is incorporated into the supply mix – is optimised through local level coordination. Many recommendations for future grid architecture include local coordination of electricity supply and demand (e.g. Refs. [11,20]. This will help to capture predicted benefits from local electricity generation including local economic development [21], and limiting the transmission losses that accumulate as electricity is transported over distances [2]. Local coordinating bodies are envisioned to act as nodes that communicate with the wider electricity system to ensure system balancing and security of supply. As with CPRs such as water, it will be necessary to coordinate governance of electricity across multiple nested governing bodies, including local electricity bodies.

As electricity systems evolve, they are becoming increasingly suited to multi-level, nested governance approaches. These approaches are well developed in research on CPRs such as water [22,23]. It is therefore useful to examine best practices for the governance of decentralised resources in order to determine how much of this applies to electricity systems, and how it can be best utilised to ensure effective and accountable electricity system governance.

3. Accountable electricity governance

Accountability is the allocation, acceptance and demonstration of responsibility for actions and decisions [7,8]. This means that, wherever there is an accumulation of power over consequential actions and decisions, there is contingent responsibility for the consequences of those actions and decisions [24]. This definition of accountability holds despite widespread confusion over what the term "governance" actually means. For some, governance

[2] Electricity is made of up electrons that move through physical wires. When numerous, uncoordinated generators and users are impacting the flow of electrons on the grid, then there are implications for the voltage and frequency of electricity. Uncoordinated fluctuations in voltage and frequency can negatively affect the stability of the system. Fluctuations in voltage and frequency are usually monitored and controlled by utilities who make use of various technological approaches to ensure system stability. However, with increased decentralisation of generation, the maintenance of system stability requires much more technical intervention. This can include placing constraints upon electricity producers, users and prosumers [102].

necessarily involves the assumption of governing responsibilities by actors beyond the state (e.g., firms, charities) (e.g. Stoker 1998; Rhodes 1996). For others, governance is the performance of governing actions (e.g., making decisions and taking actions on a particular topic), regardless of who is involved (e.g. Kooiman 2003 [105]). This means that governance could be performed solely by state actors, or solely by non-state actors. In modern resource systems, governance almost involves a mix of state and non-state actors – with consequences for who is accountable.

As electricity governance begins to incorporate more actors into decision-making processes, there are at least two significant implications for accountability; one relating to accountability mechanisms, and the other to the location of accountability itself. First, when governance expands beyond state actors, the traditional checks and balances that help ensure accountability may no longer be as relevant [24]. For example, in centralised electricity systems, governments have assumed roles as the primary accountable governing authority. In liberalised economies, they often delegate responsibilities to an arms-length regulator. By coordinating with a limited number of private generation companies, usually in relationships governed by legal contracts, regulators are able to control and ensure system reliability. If private companies do not fulfil their responsibilities, they are held accountable by contractually defined penalties [25]. If governments fail to provide reliable and cost-effective supply, they are held accountable through traditional democratic mechanisms (i.e. elections). These standard accountability relationships are disrupted when responsibility for actions and decision-making is diffused, as it is in decentralised governance contexts [24]. The electorate may still hold a government accountable (e.g. for electricity access), but, absent appropriate mechanisms, the government may no longer have the capacity to control relevant actions and decisions. This renders these accountability mechanisms less effective.

The second consequence for accountability is that decentralisation can make governing activities less transparent because there are so many decision-making nodes. As Van Kersbergen and Van Waarden (2004:158) note, "Where decision making becomes less transparent, it is less [easy] to locate *loci* of power, to identify where decisions are being taken and who is responsible." This challenge has led to a wide range of conceptualisations of accountability in decentralised governance systems.

One popular conceptualisation that has been applied to energy is that of "polycentric" governance (e.g., Ref. [5]. Polycentricity assumes multiple autonomous centres of decision making. In purely polycentric situations, there are no formally enforceable accountability mechanisms [7,19,26]. For example, bodies like the United Nations Framework Convention on Climate Change (UNFCCC) have limited capacity to sanction deviant members and must rely on external accountability mechanisms like reputation or limiting access to resources [27]. Accountability of this type is referred to as "external" and is a common characteristic of polycentric governance arrangements.

Rather than polycentricity, grid-connected decentralised generation is better characterised as a nested, multi-level governance arrangement (e.g. Refs. [28,29]. With some exceptions, the system that is emerging in most jurisdictions is of an increasing number of low to medium capacity renewable energy (RE) generators, some of whom both produce and consume electricity (i.e. prosumers) but who remain connected to a centralised grid that also includes large generation assets [1,30]. Because a grid connection is required, participation in electricity grids is not autonomous and *does* allow regulators to apply sanctions for bad behaviour (e.g. disconnection from the grid, financial penalties). This type of accountability structure is referred to as "internal" accountability [31]. It is possible that external accountability mechanisms like reputational pressure will play a stronger role in future electricity system governance – for example, in the case of small scale microgrids – but formal internal accountability mechanisms are understandably more attractive and reliable for democratically accountable governments – and are currently sufficient in situations of grid-connected generation assets.

Perhaps obviously, there is still significant uncertainty about how electricity governance can best ensure legitimate, accountable, equitable, and effective outcomes for evolving electricity systems. It is already clear that ambiguity about who is responsible for governance decisions can lead to public opposition to decentralised renewables, as well as problems securing financing from nervous investors [32]. In water governance contexts, the move to expand the range of governing actors beyond government led to a focus on the concept of "good governance". The next section describes how accountability relates to good governance, and describes the components of good governance as relevant for decentralised electricity systems.

4. Accountable, "good" governance

The concept of 'good governance' is prominent in literature that examines participatory multi-level governance (Innes et al. 2007 [104]; [24,33]). In the context of CPRs like water, 'good governance' is intended to help meet a number of criteria with both instrumental and normative implications that are viewed as desirable with respect to resource governance. These include parameters such as accountability, legitimacy and inclusion (de Loë and Kreutzwiser 2007). To illustrate, we both normatively desire accountable governance, at the same time as accountability is required to ensure that resource systems function optimally. The entanglement of normativity and functionality is inherent in participatory governance systems intending to produce just, effective and sustainable outcomes.

In 2015, the OECD hosted a participatory forum to synthesize decades of research and best practices in water governance into a set of 'good governance' principles. These principles recognize that governance is always context dependent but that there are consistent themes that provide a useful framework for analysis across contexts [34]:18). For the OECD, good governance for water is:

> the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision-makers are held accountable for water management [35].:5)

Accountability is foregrounded in this discussion as both a precondition for, and outcome of, good governance. It is also one of the seven overlapping "multi-level governance gaps" that the OECD good governance principles are designed to address (the others being policy, funding, capacity, information, administration and objectives) [34]. The forum settled upon 12 interdependent governance principles organized across 3 dimensions: *effectiveness*, *efficiency*, and *trust and engagement* (Fig. 1).

The next sections review these 12 principles, organized under the three dimensions, with special attention to their relevance for accountable decentralised governance. Empirical examples are used to clearly illustrate these principles. The examples are drawn from a case of nested, participatory water governance focused on the protection of drinking water sources in Ontario, Canada [36,37]. A brief review of the context and data collection methods for the Ontario case are first provided. The governance principles are then

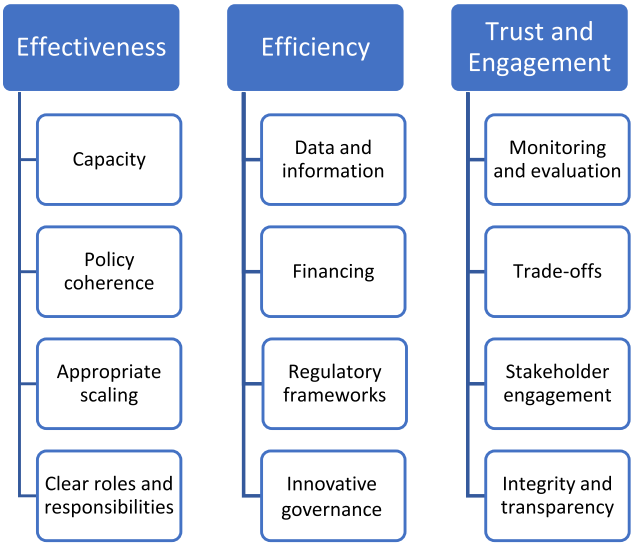

Fig. 1. OECD principles on water governance (after [35].

described and clearly related to decentralised electricity governance.

4.1. Decentralised water governance in Ontario, Canada

In 2006, the province of Ontario, Canada introduced the *Clean Water Act* (*CWA*) to address widespread governance failures. These failures culminated in a 2001 fatal incidence of municipal drinking water contamination. The *CWA* provisioned for the creation of local collaborative "Source Protection Committees" populated by civil society, businesses, and local and provincial government. The 19 provincial committees were tasked with using deliberative processes to create locally-tailored "Source Protection Plans" to govern activities with implications for drinking water sources. As a CPR, drinking water supplies across the province were impacted by a range of uses including agriculture (e.g. groundwater withdrawals for irrigation, access of cattle to streams), manufacturing, private wells, contamination from roads (e.g. road salt), small business (e.g. leakage of gas or chemical tanks), and personal uses (e.g. application of pesticides in recharge areas). This broad range of activities is the result of actions and decisions taken by many different individual actors. It required that the province, as the accountable authority, adopt a more participatory, multi-level approach than had previously been used.

The *CWA* processes were designed to correspond to what was then best practice in water governance [38]. They built heavily on the (2003) precursor document to the [35] water governance principles. As a result, they provide many clear examples of what effective nested, multi-level governance looks like in practice. These examples are useful for designing decentralised electricity governance systems. The next section reviews the 12 OECD principles, organised using the 3 dimensions of effectiveness, efficiency, and trust and engagement. Examples from the Ontario case are used to provide empirical grounding. Each dimension is then explored in the context of accountable decentralised electricity governance in a separate subsection.

4.2. Empirical data collection

The empirical examples from the Ontario case are drawn from a study examining issues of power in participatory water governance contexts where large industrial actors are active. Data for that study were generated using 41 semi-structured interviews of government officials, process participants and staff, industry actors and external experts; 92 relevant process documents; and, observations collected during participatory process meetings, site visits and interviews. These data were analysed using a theoretical framework grounded in theory on power, participation and governance through a process of analytic induction [39]. Further details on data sources and the methodological approach for the Ontario study can be found in Refs. [37,40].

5. Accountability over three dimensions of good governance

5.1. Effective governance

According to the OECD, effective governance requires decisions at appropriate scales, a clear delineation of responsibilities, sufficient capacity, and coherent policies. Much resource governance embraces principles of 'subsidiarity' where governance is devolved to the lowest appropriate level with the capacity to undertake governing functions [18]. This is often desirable because it means that governance decisions are better matched to local contexts, and incorporate local knowledge [14].

In situations where new local authorities are formed to undertake governance tasks, group formation is a highly resource intensive process. To reduce the burden of this task, new groups are often formed around existing structures. For example, the *CWA* in Ontario introduced legislation to devolve relevant aspects of drinking water governance to Source Protection Committees. These Committees were hosted by existing Conservation Authorities who received financial support from, and had formal reporting and accountability mechanisms back to, government [37]. The use of existing bodies as building blocks for new nested governance arrangements is also common in other contexts (e.g. Ref. [41]).

The decentralisation of governance activities with significant societal and legal consequences (e.g. energy provision, supply of freshwater) also usually requires that the legally accountable entity retains formal decision-making power through clear delineation of roles and responsibilities [42]. For example, when Ontario tasked Source Protection Committees with the creation of Source Protection Plans, they retained the responsibility for reviewing all plans, often sending specific decisions back to committees for renegotiation before finally signing off on them. While there were concerns that the control exerted by the province over the plans was excessive, this governance arrangement made use of local knowledge and resources to govern a decentralised system that the government was unable to effectively manage themselves, while retaining formal accountability. It is also relevant that the province heavily support committees members in developing the capacities required to make evidence-informed decisions about how to protect water sources [37,43,44].

Any devolution of responsibilities requires that those with new decision-making responsibilities have the capacities required to fulfil those responsibilities [8,23,45]. Literature on participatory resource governance has delved deeply into issues of capacity and there are a number of typologies of different capacities (e.g. Refs. [23,46]. An encompassing concept of "community capacity" has also evolved to represent the diverse capacities required to effectively govern resources at nested levels. According to Ref. [47]):1104):

> …while community capacity encompasses a variety of foundational resources or assets (e.g., physical, financial, human) upon which a community can draw in times of need, community

capacity is the interaction, mobilization, and activation of these assets toward social or institutional change.

Therefore, community capacity is not just access to different skills and types of knowledge (e.g. knowledge of policy processes, knowledge of water – or electricity – resources), but also the ability to work constructively together toward a common purpose.

Unlocking knowledge that is held by diverse actors is often part of the justification for implementing decentralised governance arrangements [48]. However, these knowledges, and related capacities are not evenly distributed and often correspond to existing societal power imbalances [49]. Capacity building in the form of workshops or information sessions is often required to make sure that all those with decision-making authority are able to make or recommend decisions from a reasonably informed perspective. In the Ontario example, participants collectively decided on the areas where they required capacity building (e.g. groundwater hydrology, cooperative decision-making). The province provided resources to ensure that these capacity needs were met [50].

The advantages of locally-led governance of resources are also balanced by risks. There is a common and somewhat natural tendency for local bodies to lose sight of the entire system and how local actions and decisions will affect others [15]. The role of a central overseeing authority, in addition to holding formal democratic responsibility for a resource, is to take a larger systems view and ensure coherence and coordination of policies [51,52]. Policy coherence requires that policy objectives, instruments, and implementation practices are aligned toward overall system optimisation across vertical and horizontal scales, as well as internally [53]. In decentralised systems, what is best for the local level may not be best for the wider system for which authorities hold formal accountability. However, negotiating this requires negotiating trade-offs (discussed in the next section). Most nested multi-level governance arrangements benefit from some form of central oversight to balance local concerns for local solutions with the interests of the larger population [54]. A central body may devolve considerable autonomy and authority to decentralised bodies but should have a clear structure in place for ensuring negotiation of best overall system functioning [18].

5.2. Effective governance for decentralised electricity systems

Issues of scale, delineation of responsibility, capacity and policy coherence are equally as important for emerging electricity governance. In the source water protection example, responsibilities were devolved to existing Conservation Authorities. However, the decentralised nature of electricity systems is a new development in many places. Decentralisation has emerged because advances in renewable energy technologies have allowed widespread decentralised electricity production [5]. Even in locations where electricity was previously decentralised (i.e. Berlin), much of the associated physical and institutional infrastructure is no longer in place [55]. Because the modern decentralised electricity system is emergent, there are not usually existing, long standing energy-focused institutions comparable to water boards or conservation authorities. Instead, municipalities [56], or other established alternative local entities (e.g. eco-communities, transition towns) are playing a key role [57,58].

In many jurisdictions, municipalities have existing authority to make some decisions about energy. For example, powers related to land use planning, zoning, building codes and infrastructure siting are often already devolved, clearly delineated, and entrenched in planning laws [59]. Many municipalities are pursuing a more active role in energy systems and using the powers they do have to support local RE development [60]. For example, the City of London has developed a suite of initiatives to enable cheap access to solar panels for citizens, the development of RE by local neighbourhood associations, a fund to support community energy development, and various mechanisms to support RE use and development in city owned infrastructure and services [61]. While not all cities have the institutional capacity of London, the surge of municipal interest in electricity is well documented [62].

Despite the logic of scale, municipalities are not always empowered to take an active role in electricity decentralisation. In Ontario, until 2019, the *Green Energy and Economy Act* provided the provincial government with the power to overrule municipal objections to the siting of specific electricity projects [63]. This type of centralised decision-making was justified based on government concerns over coherence and accountability. However, this approach has proven politically unpopular both from those seeking to stop large scale RE developments in their region, and those seeking to develop RE technologies with the support of their local municipality [64]. The resulting social conflict highlights the importance of making appropriate decisions about effective governance related to scale and the allocation of roles and responsibilities.

Accountable governance requires a clear delineation of roles and responsibilities. Bodies holding decentralised authority in nested governance arrangements must themselves have some way of ensuring internal accountability [8,16]. Governments often approach this by either devolving additional responsibilities to existing accountable authorities like municipalities, or forming new responsible groups according to specific design rules [13]. Municipal or city authorities are an attractive target for devolution because their use limits the number of layers of bureaucracy in the institutional system [65]. They are internally accountable to both citizens and higher levels of government, often have some degree of experience with regulating aspects of electricity provision, and have existing institutional capacity to govern. Whether nested, multi-level governance of electricity is formalised through municipalities or other bodies, formally accountable authorities need to commit sufficient financial and other resources to ensure that these bodies have the full range of capacities required to govern electricity.

At present, technical skills and knowledge related to the energy system are highly centralised [66]. There are a number of reasons for this: the energy system is quite complex and understanding it often requires specific, technical knowledge; broader system actors did not need to have specialized or context-specific knowledge when the system was centralized and capacities are thus not well developed [67] and; the existing profit-driven system provides incentives for electricity actors to gain politically and financially by restricting the amount of critical systems information that they share publicly. For example, there have been reports of grid operators controlling both technical regulatory rule setting and critical systems data in order to maintain political leverage in many locations [68–70]. A decentralised system will need to build technical knowledge and skills amongst decentralised actors, not just the previous incumbents.

Building electricity governance capacities at decentralised levels is an inherently political act because it facilitates a reorganisation of who owns, operates, and benefits – fiscally and socially – from the electricity system [66,68]. However, these capacities are also required to have a *functional* decentralised governance system. This is part of the reason why decentralised, grid connected systems are also often described as, to greater or lesser degrees, more democratised [71]).

Decentralised governance of electricity will also require a strong central coordination mechanism in order to ensure policy

coherence across scales and policy and regulatory components [67,72]. While much planning and balancing can be done at the local level, increasing population density in urban areas and the inherent intermittency of many renewables means that it remains both beneficial and necessary to balance aggregated supply, storage, and demand across larger areas [11]. For many countries, a centralised coordination body is also necessary because of participation in international electricity markets and the need to respond to electricity dynamics in other countries.

Whatever entity is assigned the coordination role, coordination should not be confused with control. When central authorities attempt to retain too much control, it can lead to public opposition and can supress innovation and development [24,64]. At the same time, there is fear amongst accountable central authorities that too little control will lead to an electricity system where those without the capacity to develop decentralised resources will be left behind. In effective electricity governance regimes, central coordinating authorities will likely cede considerable autonomy to decentralised authorities who are best placed to manage issues like siting, grid access, and local balancing. However, there is also a need for a clear structure for ensuring negotiation of best overall system functioning that balances local and larger system concerns and ensures policy coherence across scales.

5.3. Trustworthy and engaged governance

The OECD framework stipulates that good governance includes broad stakeholder engagement, monitoring and evaluation, consideration of trade-offs between actors, and integrity and transparency. Good governance requires effective engagement of stakeholders because many resource governance challenges cannot be solved by any one actor working on their own. Smaller groups working together in a coordinated fashion are often better able to tackle large collective problems because they are able to integrate local knowledge and contexts into their decisions. This also promotes feelings of ownership over decisions that help to ensure compliance with co-developed rules and regulations. In many resource governance contexts, even if central authorities attempt to make strict rules, the costs of monitoring, policing behaviour, and sanctioning non-compliance are often much higher than taking a more participatory approach [14,17,73,]. For this reason, much decentralised resource governance emphasizes participation and deliberation [48].

Participatory approaches are useful for managing trade-offs between actors. In situations where individual, decentralised actors make decisions that impact the ability of others to use a common resource, approaches that allow for the negotiation of rules and trade-offs are desirable [14,75]. In Ontario, source water protection planning used consensus-oriented decision making that focused on dialogue and debate in order to negotiate compromises [37]. While full deliberative processes are not always necessary to resolve all trade-offs, there are a range of participatory models that can be used to develop governance decisions. These models run the gamut from information dissemination to consultation sessions to full collaborative processes. The amount of participation required often depends on the degree to which broad cooperation is required in order to achieve desired outcomes [76].

More decentralised approaches are assumed to be more legitimate and transparent. This is assumed to facilitate accountability [24,48]. However, the openness of decentralised governance depends very much on who sets the governing agenda and how problems are defined. For example, in the Ontario case, the problem was predefined by the responsible authority to focus only on the protection of municipal drinking water supplies from a list of official “threats”. While the accountable authority felt the need to constrain the process to ensure it was politically palatable and feasible, the restrictions on content meant that not everyone was happy with the process. There are also outstanding water issues that remain to be addressed because they were kept “off the table” of collaborative decision making for political reasons (e.g. contamination resulting from aggregate extraction) [37]. The government retained formal accountability but this was done at the expense of consideration of the full range of relevant issues.

5.4. Trustworthy and engaged electricity governance

Drawing lessons from multi-level water governance, decentralised electricity governance will benefit from the active inclusion of a wide range of involved and impacted actors, consideration of trade-offs, and attention to both monitoring and evaluation, and integrity and transparency. Broad participation of the many new actors who are involved in electricity systems will be required to ensure broader system functioning. These actors will be able to improve and legitimise decisions on, for example, the specific types of capacity and expertise that need to be built and shared, who will provide specific training, and how expertise will be shared [37,77].

Most visions for a decentralised grid rely heavily on smart meters for monitoring, coordination and the balancing of trade-offs [78]. However, smart metering is not a panacea [79]. The inclusion of decentralised electricity producers in decision-making processes should, if done properly, make it easier to ensure compliance with technical system needs (i.e., distribution to, and consumption from, the grid at appropriate times) that cannot be managed solely through smart technologies. This also means opening up formerly closed technical processes such as regulatory code panels to a broader range of actors. This will facilitate the broad inclusion of actors in developing the technical rules that govern the emerging electricity system [69]. Perhaps most importantly, participatory governance can help facilitate social acceptance of the rules required to ensure a functional electricity grid that can provide sufficient and reliable supply.

The EU Clean Energy Package [80] already provisions for some of the governance components needed for a transparent and engaged decentralised governance system. These provisions are in reference to Renewable Energy Communities (RECs),[3] but are relevant for wider governance systems. In particular, RECs are defined by open, non-discriminatory participation. Decision-making is also structured to avoid capture by any one single group. These provisions are useful for ensuring transparency, sustained stakeholder engagement, and overall levels of trust and social acceptance.

5.5. Efficient governance

The OECD *efficiency* governance dimension requires attention to data and information, financing, regulatory frameworks and innovation. Effective governance of any resource, decentralised or otherwise, requires high quality information. In order for wider groups of people to make good decisions, they need to have access to relevant system information. In the Ontario example, this meant information on surface and groundwater movement, contaminant sources, and water demands. Depending on contextually-specific conditions, information may be hidden or guarded to protect certain interests (e.g. information on contaminants), or simply as a result of bureaucratic tradition or inefficiency. Again, negotiating release of these data can be a political process, especially when

[3] RECs are also defined by restricted ownership rules (i.e., only natural persons, SMEs, and local authorities), by primary motivations that extend beyond financial profitability, and by local ownership.

interests claim that information is proprietary [50] However, the effectiveness of governance is limited by incomplete information.

Decentralised resource governance in particular is useful in revealing data gaps. For example, the collaborative source water protection exercise in Ontario revealed that many of the groundwater resources in the province had not been adequately mapped. For years, decisions had been made with incomplete information, often to the detriment of actual outcomes [81]. In order to provide the collaborative committees with sufficient information, the province invested significant financial resources in groundwater studies that, by many accounts, should have been completed years prior [82]. The participation of previously unengaged actors also brings more local and contextually-relevant information into the governance process, improving data quality [48].

Within natural resource domains, there has been a tendency for centralised governments to delegate responsibility for tasks without the associated authority or financing required to make and implement decisions. This usually leads to governance failures whereby bodies responsible for certain governance functions are unable to carry out them out effectively [83]. Municipalities in particular often resist the devolution of responsibility because this has historically happened without an associated devolution of resources [84]. Devolution of responsibility thus needs to be accompanied by appropriate changes to regulatory and policy frameworks.

In decentralised water governance contexts, the innovative governance principle manifests as a focus on reflexivity and adaptive governance [23]. This requires specific capacities related to program review and evaluation (discussed above), flexibility, and experimentation [85]. In many cases, decentralised bodies are better placed to be responsive to changing local conditions because they are physically and institutionally closer to problem areas. However, as with many other capacities, the ability to be responsive is not necessarily inherent and must be specifically developed and financially supported [17].

Scholarship on resource governance reveals other capacities required for multi-level governance systems to be innovative and adaptive [23]. Decentralised authorities need to have the ability to build and broker knowledge. In situations where resources are decentralised and shaped by local contexts, decentralised governance bodies cannot feasibly have all the knowledge they need to govern in-house. Local authorities need to be able to build, co-produce, and draw upon networks to fill in knowledge and capacity gaps [86,87]. This reflexive and adaptive governance reflects a continual tension between ensuring institutional consistency and trust, and making changes to adapt to changing circumstances. The ability to be flexible is aided by interrelated governance principles including clear roles and responsibilities, participation, engagement and transparency.

5.6. *Efficient governance of electricity systems*

Data and information, financing, regulatory frameworks and innovation are also necessary in decentralised electricity governance systems. Data is crucial for decentralised energy systems and has been the subject of significant academic interest in the context of electricity supplies and smart technologies (e.g., Refs. [88,89]). In particular, balancing decentralised, intermittent supplies over broad, multi-level networks requires a great deal of coordination. The ongoing decentralisation of supply to the centralised grid has revealed just how important it is to have good, transparent data on how much capacity the grid can handle, and the specifics of loading [9,90].

In order for decentralised electricity governance to work well, decentralisation of supply needs to be accompanied by open availability of energy systems data [91]. This is less of a problem in the European Union where regulations mandate ‘unbundling’ of generation and distribution. Under current EU regulation, the companies controlling information on, for example, how much distributed generation the wires in a specific region can handle are not the same companies competing with distributed generators for supply contracts [92]. This reduces the incentive for companies to withhold data in the name of competitive advantage. However, there are many jurisdictions, particularly in North America, where generation and supply are not completely separate. This has created predictable political problems with data availability. Even in the EU, regulatory standard setting is often controlled by actors linked to the centralised system and thus proceeds slowly as those actors act to protect their financial interests - [69].

Issues of financing are also vital for decentralised energy systems. One of the key questions for regulators and grid operators concerns who will pay for the system upgrades required to decentralise supply [67]. As with other resource governance contexts, many visions for future grid charging regimes explore a balance of financing responsibilities between grid users and the responsible or accountable authority [90]. Grid charges are politically contentious, and many governments and regulators are struggling to balance new charging regimes with social acceptability (e.g. Ref. [93]). This area is under researched but, as with other aspects of energy systems change, the development of financing rules will itself require effective, transparent and efficient governance.

There are also specific legal and regulatory capacities that need to be built specific to a decentralised electricity system [94]. There are emerging models for rules and ‘smart’ contracts to simplify integration of decentralised supply [95]. However, making good decisions about how to use such contracts to support the larger public good requires understanding how they work. This then overlaps with knowledge and capacity building requirements for effective governance, discussed above.

There are emerging examples of governments that are supportive of decentralised generation beginning to develop policies and regulations for nested, multi-level governance arrangements. For example, the Netherlands approved a Climate Accord in June 2018 with a non-binding provision that 50% of all renewable energy moving forward would be community-owned. This was done to facilitate social acceptance of the renewables infrastructure that will be needed to meet aggressive Dutch climate targets. The Climate Accord was preceded by an Environment and Planning Act, to be entered into force in 2019, with specific provision allowing local experimentation with electricity regulations. The Act requires cooperation between municipalities and grid operators regarding RE. Together, these two pieces of legislation both structure and support decentralisation of energy in a manner than provisionally supports clear chains of accountability, enshrined in regulation [103].

Finally, decentralised governance bodies need to have the ability to build and broker knowledge to accommodate the rapid pace of change in the energy sector. This includes building and drawing upon networks to both coordinate electricity systems and to fill in knowledge and capacity gaps [6,96]. Related, these bodies must be able to be reflexive and adaptable to changing conditions [97]. Given the rapidly changing energy system profile, the capacity of decentralised bodies to experiment and innovate within their remit will also help central coordinating bodies ensure that they are meeting their responsibilities to govern energy in step with social and technological developments. Many countries have experimentation directives that allow a relaxation of regulatory rules under controlled circumstances in order to test out different technological and regulatory arrangements (e.g. Ref. [9]). These types of

forums can be useful to test the feasibility of different arrangements, although there are arguments that they are too protective of the status quo [9,68].

Regulatory experimentation should also not preclude or supersede action by decentralised governance bodies. Some municipalities already have authority to make more consequential decisions about electricity regulations. Locations where the grid and local utility are under local public ownership often have more freedom to establish regulatory allowances like "net metering" where producers are paid for electricity that they feed back in to the grid. This is the case in Cape Town, South Africa where municipalities have a significant influence over local utilities, and have established both net metering, and an expansive plan for the development of decentralised renewable energy [98].

6. Conclusions

The governance choices made by accountable authorities now will define electricity systems for years to come. While there is widespread acceptance that the future of energy will be at least partially decentralised, there are conflicting views about how such a system can and should be structured and governed [32,96,99]. Existing accountability mechanisms for electricity evolved in step with centralised systems. As these systems change, there is a need to adapt governance models to ensure overall electricity system reliability, access and affordability [5]. While decentralisation of grid-connected generation is a contemporary development in many locations, decentralisation is an inherent part of other resource systems such as water. There are valuable lessons to be learned by examining best practices for nested, multi-level governance of natural resources.

As established, the comparison between grid-connected electricity and water is imperfect. This is especially true at present as levels of prosumption and distributed ownership of electricity are still limited. However, falling costs of technology, combined with increasing concern over CO_2 emissions, are leading to exponential increases in deployment of decentralised generation technologies. While developing a governance system that treats electricity as a CPR may seem unnecessary under current conditions, sociotechnical trends indicate that this type of anticipatory governance will help unlock the benefits of decentralisation, while facilitating the broad engagement in the energy transition that is necessary to facilitate social acceptance of the changes to come [4].

This analysis has revealed a number of insights specifically relevant for addressing accountability in decentralised electricity governance. As mentioned, decentralisation of at least some governance functions will be necessary to optimise overall electricity system functioning, and promote public acceptance of RE and engagement in demand-side activities. However, decentralisation will be most appropriate if governing tasks are broadly participatory, allocated to the lowest appropriate level, designed with adequate internal accountability mechanisms, and with attention to ensuring adequate capacities, financing and powers.

Transparent inclusion, coherence and data sharing mechanisms are perhaps even more important for electricity than for water because of ongoing challenges associated with storing large amounts of electricity, and the consequent need to instantaneously balance supply and demand. If the balance between participation and system coordination is not well managed (i.e. if accountable authorities tend toward too much control, if authorities unduly restrict the scope of governance activities undertaken by collaborative bodies), there is the potential for grid defection by those with sufficient resources. That could mean that the burden of paying for the costs of public grid infrastructure increasingly fall on the less privileged who are unable to set up private electricity systems [100]. For accountable authorities, this is a balance that must be carefully negotiated.

The level of uncertainty in the energy sector is unprecedented [101]. There is no analogue for this level of long-term volatility in water or other resource governance sectors. While the OECD governance principles highlight innovation, transparency, adaptiveness and reflexivity, the degree to which decentralised electricity governance systems will need to assume these characteristics is much more pressing. This makes an even stronger case for addressing current governance gaps related to data availability, appropriate scaling, and system coherence. Knowledge, capacities and skills development for the non-traditional actors with roles to play in future electricity system governance is also essential in this scenario.

The evolving nature of the electricity system has limited the availability of empirical examples of decentralised electricity governance for use in this paper. These systems are rapidly evolving and practice-led (e.g. New York's *Reforming the Energy Vision* strategy; the U.K. Labour Party's grid nationalisation strategy, *Bringing Energy Home)*. Even where these systems are more advanced, academic literature is still lagging behind. For this reason, the arguments presented in this paper are forward looking, based on expertise in other sectors. However, this a research and practical gap that, of necessity, will be addressed quickly.

Finally, the recommendations in this article are based on current sociotechnical trajectories in the electricity sector toward increased prosumption, consumer participation and broad decentralisation. It is also possible that electricity systems of the future could look very different, dependent upon technical advancement and upon historical contexts, political trends, and existing institutional legacies. Effective governance is, and will always be, context dependent. The OECD principles in and of themselves are guidelines only. However, attending to broad principles of good governance are one way to achieve a "no regrets" approach to electricity system governance under current conditions of high uncertainty.

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References

[1] International Energy Agency, 2018 world energy outlook, 2018.
[2] Mudathir Funsho Akorede, Hashim Hizam, Edris Pouresmaeil, Distributed energy resources and benefits to the environment, Renew. Sustain. Energy Rev. 14 (2) (2010) 724–734.
[3] James Keirstead, Behavioural responses to photovoltaic systems in the UK domestic sector, Energy Policy 35 (8) (2007) 4128–4141, https://doi.org/10.1016/j.enpol.2007.02.019.
[4] Lucas Roth, Jens Lowitzsch, Özgür Yildiz, Alban Hashani, Does (Co-) ownership in renewables matter for an electricity consumer's demand flexibility? Empirical evidence from Germany, Energy Res. Soc. Sci. 46 (2018) 169–182.
[5] Andreas Goldthau, Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism, Energy Res. Soc. Sci. 1 (2014) 134–140.
[6] Aleh Cherp, Jessica Jewell, Andreas Goldthau, Governing global energy: systems, transitions, complexity, Glob. Policy 2 (1) (2011) 75–88.
[7] Frank Biermann, Aarti Gupta, Accountability and legitimacy in earth system governance: a research framework, Ecol. Econ. 70 (11) (2011) 1856–1864.
[8] Michael Lockwood, Julie Davidson, Allan Curtis, Elaine Stratford, Rod Griffith,

Governance principles for natural resource management, Soc. Nat. Resour. 23 (10) (2010) 986–1001.
[9] Imke Lammers, Lea Diestelmeier, Experimenting with law and governance for decentralized electricity systems: adjusting regulation to reality? Sustainability 9 (2) (2017) 212.
[10] Rob C de Loë, James J. Patterson, Rethinking water governance: moving beyond water-centric perspectives in a connected and changing world, Nat. Resour. J. 57 (2017) 75.
[11] Ali M. Adil, Yekang Ko, Socio-technical evolution of decentralized energy systems: a critical review and implications for urban planning and policy, Renew. Sustain. Energy Rev. 57 (2016) 1025–1037.
[12] Rod A.W. Rhodes, Understanding governance: ten years on, Organ. Stud. 28 (8) (2007) 1243–1264.
[13] Michael Lockwood, Julie Davidson, Allan Curtis, Elaine Stratford, Rod Griffith, Multi-level environmental governance: lessons from Australian natural resource management, Aust. Geogr. 40 (2) (2009) 169–186.
[14] E. Ostrom, Governing the Commons: the Evolution of Institutions for Collective Action, Cambridge University Press, " Cambridge, 1990.
[15] Yannis Papadopoulos, Accountability and multi-level governance: more accountability, less democracy?, in: Accountability and European Governance Routledge, 2014, 112–31.
[16] Neil Gunningham, The new collaborative environmental governance: the localization of regulation, J. Law Soc. 36 (1) (2009) 145–166.
[17] Carina Wyborn, R Patrick Bixler, Collaboration and nested environmental governance: scale dependency, scale framing, and cross-scale interactions in collaborative conservation, J. Environ. Manag. 123 (2013) 58–67.
[18] Graham R. Marshall, Nesting, subsidiarity, and community-based environmental governance beyond the local level, Int. J. Commons 2 (1) (2008) 75–97.
[19] Dave Huitema, Erik Mostert, Wouter Egas, Sabine Moellenkamp, Claudia Pahl-Wostl, Resul Yalcin, Adaptive water governance: assessing the institutional prescriptions of adaptive (Co-) management from a governance perspective and defining a research agenda, Ecol. Soc. 14 (1) (2009) 26.
[20] David Roberts, Clean energy technologies threaten to overwhelm the grid. Here's how it can adapt. Vox (2018). December 2018, https://www.vox.com/energy-and-environment/2018/11/30/17868620/renewable-energy-power-grid-architecture.
[21] Matthew J. Burke, Jennie C. Stephens, Energy democracy: goals and policy instruments for sociotechnical transitions, Energy Res. Soc. Sci. 33 (2017) 35–48.
[22] Giorgos Kallis, Michael Kiparsky, Richard Norgaard, Collaborative governance and adaptive management: lessons from California's CALFED water program, Environ. Sci. Policy 12 (6) (2009) 631–643.
[23] James J. Patterson, Carl Smith, Jennifer Bellamy, Understanding enabling capacities for managing the 'wicked problem' of nonpoint source water pollution in catchments: a conceptual framework, J. Environ. Manag. 128 (2013) 441–452, https://doi.org/10.1016/j.jenvman.2013.05.033.
[24] Kees Van Kersbergen, Frans Van Waarden, "'Governance'as a bridge between disciplines: cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy, Eur. J. Political Res. 43 (2) (2004) 143–171.
[25] Karin Gottschall, Bernhard Kittel, Kendra Briken, Jan-Ocko Heuer, Sylvia Hils, Sebastian Streb, Markus Tepe, Energy regulatory agencies, in: Public Sector Employment Regimes: Transformations of the State, Palgrave Macmillan, London, 2015, 167–96.
[26] Susan Park, Kramarz Teresa (Eds.), Global Environmental Governance and the Accountability Trap, MIT Press, London, 2019.
[27] Oscar Widerberg, Philipp Pattberg, Accountability challenges in the transnational regime complex for climate change, Rev. Policy Res. 34 (1) (2017) 68–87.
[28] Jens Marquardt, How Power Shapes Energy Transitions in Southeast Asia: A Complex Governance Challenge, Routledge, 2016.
[29] Benjamin K. Sovacool, An international comparison of four polycentric approaches to climate and energy governance, Energy Policy 39 (6) (2011) 3832–3844.
[30] François Bouffard, Daniel S. Kirschen, Centralised and distributed electricity systems, Energy Policy 36 (12) (2008) 4504–4508.
[31] Robert O. Keohane, Global governance and democratic accountability, in: David Held, Mathias Koenig Archbugi (Eds.), In *Taming Globalization: Frontiers of Governance*, 2003, 130–59. Oxford: Polity.
[32] Richard Cowell, Decentralising energy governance? Wales, devolution and the politics of energy infrastructure decision-making, Environ. Plan. C Soc. Sci.: Polit. Space 35 (7) (2017) 1242–1263.
[33] Peter Rogers, Alan W. Hall, Effective Water Governance, vol. 7, Global water partnership, 2003.
[34] Aziza Akhmouch, Francisco Nunes Correia, "The 12 OECD principles on water governance – when science meets policy, Util. Policy 43 (2016) 14–20, https://doi.org/10.1016/j.jup.2016.06.004.
[35] OECD, OECD principles on water governance, 2015.
[36] Brisbois, Marie Claire, R.C. de Loë, Natural resource industry involvement in collaboration for water governance: influence on processes and outcomes in Canada, J. Environ. Plan. Manag. 60 (5) (2017), https://doi.org/10.1080/09640568.2016.1182899.
[37] Brisbois, Marie Claire, R.C. de Loë, State roles and motivations in collaborative approaches to water governance: a power theory-based analysis, Geoforum 74 (2016), https://doi.org/10.1016/j.geoforum.2016.06.012.
[38] Integrated Environmental Planning Division, "White Paper on Watershed-Based Source Protection." Toronto, 2004. http://hdl.handle.net/10214/15837.
[39] Michael Bloor, Fiona Wood, Keywords in Qualitative Methods: A Vocabulary of Research Concepts, Sage, 2006.
[40] Brisbois, Marie Claire, Rob C de Loë, Natural resource industry involvement in collaboration for water governance: influence on processes and outcomes in Canada, Environ. Plan. Manag. Online (2016).
[41] Michael Kiparsky, Anita Milman, Dave Owen, T Andrew Fisher, The importance of institutional design for distributed local-level governance of groundwater: the case of California's sustainable groundwater management act, Water (2017), https://doi.org/10.3390/w9100755.
[42] Tomas M. Koontz, Toddi A. Steelman, JoAnn Carmin, Katrina Smith Korfmacher, Cassandra Moseley, Craig W. Thomas, Collaborative Environmental Management: what Roles for Government-1, Routledge, 2010.
[43] Christina Cook, Implementing drinking water security: the limits of source protection, Wiley Interdiscip. Rev.: Water 3 (1) (2016) 5–12.
[44] J. Baird, J. Velaniškis, R. Plummer, J. Fitzgibbon, Political legitimacy and collaborative water governance: an exploratory case study, Int. J. Water Gov. 2 (1) (2014).
[45] Ben Bradshaw, Questioning the credibility and capacity of community-based resource management, Can. Geogr./Le Géographe Canadien 47 (2) (2003) 137–150.
[46] Beckley, M. Thomas, Diane Martz, Solange Nadeau, Ellen Wall, Bill Reimer, Multiple capacities, multiple outcomes: delving deeper into the meaning of community capacity, J. Rural Community Dev. 3 (3) (2009).
[47] Mae A. Davenport, Erin Seekamp, A multilevel community capacity model for sustainable watershed management, Soc. Nat. Resour. 26 (9) (2013) 1101–1111.
[48] Chris Ansell, Alison Gash, Collaborative governance in theory and practice, J. Public Adm. Res. Theory 18 (4) (2008) 543–571.
[49] Candace K. May, Visibility and invisibility: structural, differential, and embedded power in collaborative governance of fisheries, Soc. Nat. Resour. 29 (7) (2016) 759–774.
[50] Brisbois, Marie Claire, C. Rob, de Loë, Natural resource industry involvement in collaboration for water governance: influence on processes and outcomes in Canada, J. Environ. Plan. Manag. 60 (5) (2017) 883–900, https://doi.org/10.1080/09640568.2016.1182899.
[51] Brent Taylor, Rob de Loe, Kreutzwiser Reid, Henning Bjornlund, Local groundwater management studies in Ontario, Canada: a case for retaining a role for the state in community-based water research, Aust. J. Water Resour. 13 (1) (2009) 69–80.
[52] Ian Bache, Ian Bartle, Matthew Flinders, Greg Marsden, Blame games and climate change: accountability, multi-level governance and carbon management, Br. J. Polit. Int. Relat. 17 (1) (2015) 64–88.
[53] Måns Nilsson, Tony Zamparutti, Jan Erik Petersen, Björn Nykvist, Rudberg Peter, Jennifer McGuinn, "Understanding policy coherence: analytical framework and examples of sector–environment policy interactions in the EU, Environ. Policy Gov. 22 (6) (2012) 395–423, https://doi.org/10.1002/eet.1589.
[54] Neil Gunningham, Robert A. Kagan, Dorothy Thornton, Social license and environmental protection: why businesses go beyond compliance, Law Soc. Inq. 29 (2) (2004) 307–341.
[55] Timothy Moss, Maria Francesch-Huidobro, Realigning the electric city. Legacies of energy autarky in Berlin and Hong Kong, Energy Res. Soc. Sci. 11 (2016) 225–236, https://doi.org/10.1016/j.erss.2015.10.002.
[56] Harriet Bulkeley, Castán Broto Vanesa, Mike Hodson, Simon Marvin, Cities and Low Carbon Transitions, Routledge, 2010.
[57] Siddharth Sareen, Baillie Douglas, Jürgen Kleinwächter, Transitions to future energy systems: learning from a community test field, Sustainability (2018), https://doi.org/10.3390/su10124513.
[58] Gill Seyfang, Alex Haxeltine, Growing grassroots innovations: exploring the role of community-based initiatives in governing sustainable energy transitions, Environ. Plan. C Govern. Policy 30 (3) (2012) 381–400.
[59] Thomas Hoppe, van Bueren Ellen, Guest editorial: governing the challenges of climate change and energy transition in cities, SpringerOpen (2015).
[60] Harriet Bulkeley, Castán Broto Vanesa, Anne Maassen, Low-carbon transitions and the reconfiguration of urban infrastructure, Urban Stud. 51 (7) (2014) 1471–1486, https://doi.org/10.1177/0042098013500089.
[61] London City of 2019, "Energy for Londoners.", 2019.
[62] Jonathan Rutherford, Olivier Coutard, Urban energy transitions: places, processes and politics of socio-technical change, Urban Stud. 51 (7) (2014) 1353–1377.
[63] Stewart Fast, Warren Mabee, Jamie Baxter, Tanya Christidis, Liz Driver, Stephen Hill, J.J. McMurtry, Melody Tomkow, Lessons learned from Ontario wind energy disputes, Nat. Energy 1 (2) (2016) 15028.
[64] Daniel Rosenbloom, James Meadowcroft, The journey towards decarbonization: exploring socio-technical transitions in the electricity sector in the province of Ontario (1885–2013) and potential low-carbon pathways, Energy Policy 65 (2014) 670–679.
[65] Anne M. Larson, C Ribot Jesse, Democratic decentralisation through a natural resource lens: an introduction, Eur. J. Dev. Res. 16 (1) (2004) 1–25.
[66] Matthew J. Burke, Jennie C. Stephens, Political power and renewable energy futures: a critical review, Energy Res. Soc. Sci. (2017), https://doi.org/10.1016/j.erss.2017.10.018.

[67] Nick Eyre, Sarah J Darby, Philipp Grünewald, Eoghan McKenna, Rebecca Ford, Reaching a 1.5 C target: socio-technical challenges for a rapid transition to low-carbon electricity systems, Philos. Trans. R. Soc. A Math. Phys. Eng. Sci. 376 (2119) (2018) 20160462.
[68] Brisbois, Marie Claire, Powershifts: a framework for assessing the growing impact of decentralized ownership of energy transitions on political decision-making, Energy Res. Soc. Sci. 50 (2019) 151–161.
[69] Matthew Lockwood, Catherine Mitchell, Ricard Hoggett, Governance of industry rules and energy system innovation: the case of codes in great britain, Util. Policy 47 (2017) 41–49.
[70] Ross Astoria, "On the radicality of New York's reforming the energy vision, Electr. J. 30 (5) (2017) 54–58, https://doi.org/10.1016/j.tej.2017.04.018.
[71] Thombs, P. Ryan, When democracy meets energy transitions: a typology of social power and energy system scale, Energy Res. Soc. Sci. 52 (2019) 159–168.
[72] Karoline S. Rogge, Florian Kern, Michael Howlett, Conceptual and empirical advances in analysing policy mixes for energy transitions, Energy Res. Soc. Sci. 33 (2017) 1–10.
[73] Arun Agrawal, Studying the commons, governing common-pool resource outcomes: some concluding thoughts, Environ. Sci. Policy 36 (2014) 86–91.
[75] Jayanath Ananda, Wendy Proctor, Collaborative approaches to water management and planning: an institutional perspective, Ecol. Econ. 86 (2013) 97–106.
[76] Jens Newig, Oliver Fritsch, Environmental governance: participatory, multi-level–and effective? Environ. Policy Gov. 19 (3) (2009) 197–214.
[77] Svein Jentoft, In the power of power: the understated aspect of fisheries and coastal management, Hum. Organ. (2007) 426–437.
[78] Simon Funcke, Dierk Bauknecht, Typology of centralised and decentralised visions for electricity infrastructure, Util. Policy 40 (2016) 67–74.
[79] Maarten Wolsink, The research agenda on social acceptance of distributed generation in smart grids: renewable as common pool resources, Renew. Sustain. Energy Rev. 16 (1) (2012) 822–835.
[80] European Commission, Clean Energy for All Europeans, 2019.
[81] Steve Holysh, Richard Gerber, Groundwater knowledge management for southern Ontario: an example from the Oak Ridges Moraine, Can. Water Res. J./Revue Canadienne Des Ressources Hydriques 39 (2) (2014) 240–253.
[82] Rob C de Loë, Reid D. Kreutzwiser, Closing the groundwater protection implementation gap, Geoforum 36 (2) (2005) 241–256.
[83] Jesse C. Ribot, Choosing representation: institutions and powers for decentralized natural resources management, in: The Politics of Decentralization, Routledge, 2012, pp. 100–120.
[84] Anne M. Larson, Fernanda Soto, Decentralization of natural resource governance regimes, Annu. Rev. Environ. Resour. 33 (2008) 213–239.
[85] Nathan Engle, Johns Owen, Carmen Lemos Maria, Donald Nelson, Integrated and adaptive management of water resources: tensions, legacies, and the next best thing, Ecol. Soc. 16 (1) (2011).
[86] Fikret Berkes, Devolution of environment and resources governance: trends and future, Environ. Conserv. 37 (4) (2010) 489–500.
[87] Derek Armitage, Fikret Berkes, Nancy Doubleday, Adaptive Co-management: Collaboration, Learning, and Multi-Level Governance, UBC Press, 2010.
[88] Boardman, Ethan Clair, and Subrahmanyam Saraswati Venkata. 2015. "Intelligent electrical distribution grid control system data."Google Patents.
[89] F Richard Yu, Peng Zhang, Weidong Xiao, Paul Choudhury, Communication systems for grid integration of renewable energy resources, IEEE Netw. 25 (5) (2011) 22–29.
[90] James Newcomb, Virginia Lacy, Lena Hansen, Mathias Bell, Distributed energy resources: policy implications of decentralization, Electr. J. 26 (8) (2013) 65–87.
[91] Jürgen Meister, Ihle Norman, Sebastian Lehnhoff, Mathias Uslar, 10 - smart grid digitalization in Germany by standardized advanced metering infrastructure and green button, in: Lisa Ann Lamont, B.T. Ali (Eds.), Application of Smart Grid Technologies Sayigh, Academic Press, 2018, https://doi.org/10.1016/B978-0-12-803128-5.00010-6, 347–71.
[92] Tooraj Jamasb, Michael Pollitt, Electricity market reform in the European union: review of progress toward liberalization & integration, Energy J. (2005) 11–41.
[93] Benjamin K. Sovacool, Rejecting renewables: the socio-technical impediments to renewable electricity in the United States, Energy Policy 37 (11) (2009) 4500–4513.
[94] Karoline S. Rogge, Benjamin Pfluger, Frank W. Geels, Transformative policy mixes in socio-technical scenarios: the case of the low-carbon transition of the German electricity system (2010–2050), Technol. Forecast. Soc. Chang. (2018).
[95] Lee Thomas, Yue Zhou, Chao Long, Jianzhong Wu, Nick Jenkins, A general form of smart contract for decentralized energy systems management, Nat. Energy 4 (2) (2019) 140–149, https://doi.org/10.1038/s41560-018-0317-7.
[96] Kristina Hojčková, Björn Sandén, Ahlborg Helene, Three electricity futures: monitoring the emergence of alternative system Architectures, Futures 98 (2018) 72–89, https://doi.org/10.1016/j.futures.2017.12.004.
[97] Johan Schot, W Edward Steinmueller, Framing Innovation Policy for Transformative Change: Innovation Policy 3.0, *SPRU Science Policy Research Unit, University of Sussex*, Brighton, UK, 2016.
[98] Sylvy Jaglin, Urban energy policies and the governance of multilevel issues in Cape town, Urban Stud. 51 (7) (2014) 1394–1414.
[99] Johan Lilliestam, Susanne Hanger, Shades of green: centralisation, decentralisation and controversy among European renewable electricity visions, Energy Res. Soc. Sci. 17 (2016) 20–29.
[100] Lucy Baker, Jon Phillips, Tensions in the transition: the politics of electricity distribution in South Africa, Environ. Plan. C Soc. Sci.: Polit. Space 37 (1) (2019) 177–196.
[101] International Energy Agency, World Energy Outlook 2019, 2019.
[102] S.N. Singh, Østergaard Jacob, Naveen Jain, Distributed generation in power systems: an overview and key issues, in: Proceedings of the 24th Indian Engineering Congress. Kerala, India, 2009.
[103] Brisbois, Marie Claire. n.d. "Rescaling, reorganization and battles for influence: shifting political power in an era of electricity decentralization.".
[104] J. Innes, S. Connick, D. Booher, et al., Collaborative water management in the CALFED Bay-Delta program, J. Am. Plan. Assoc. 73 (2) (2007) 195–210.
[105] J. Kooiman. Governing As Governance., SAGE Publications Ltd., London, United Kingdom, 2003.